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Farm diversity, resource use efficiency and sustainable land management in the western highlands of Kenya

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A B S T R A C T

Sub-Saharan Africa (SSA) faces further population growth in the coming decades and it is essential to increase food production in rural areas. However, development programs to enhance agricultural productivity have achieved mixed results. This study investigates farm household responses to a changing agro-environment in one of the most densely populated rural districts in SSA and examines practical implications for the promotion of sustainable land management (SLM) practices. The specific objective is to analyze farm diversity and resource use efficiency and their implications for promoting SLM in the highlands of Western Kenya. We carried out an elaborate survey of 236 households, and applied multivariate analysis to analyze farm efficiency and livelihood strategies. We found major differences in responses to a changing agro-environment between five farm types in terms of resource endowment, income strategies and farm practices. Across farm types, efficiency was low indicating poor land productivity. Our study shows that there has been a lack of intensification in land use and that households are increasingly depending on off-farm income. Our findings have a number of implications to programs aiming to promote sustainable land management in SSA. We propose that successful implementation of such programs requires targeting areas highly reliant on agriculture and within these areas focus on households mostly dependent on farming to sustain their welfare.

1. Introduction

In order to feed a growing population, land productivity and *per capita* food production need to increase in the coming decades in Sub-Saharan Africa (SSA) (Clover, 2003; Lambin et al., 2003). It has been postulated that rising rural population densities lead to intensification of agricultural production (Boserup, 1965; Hayami and Ruttan, 1985; Pender, 1998; Tiffen et al., 1994). However, at the same time, there is a concern that increasing pressure on agricultural land, in the absence of better land management, leads to land degradation. A range of studies point to land degradation constraining agricultural output in many parts of the continent (e.g. Barbier, 2000; Crowley and Carter, 2000; Jayne et al., 2010; Longley et al., 2006; Nkonya et al., 2009; Odendo et al., 2009; Pender, 1998). Consequently, widespread promotion of more efficient and sustainable agricultural techniques, for the purpose of this paper termed sustainable land management (SLM) practices is required to reconcile increasing population density and increased agricultural productivity (Lambin, 2012; Odendo et al., 2009; Pender, 1998).

A variety of development programs aiming to promote SLM and related concepts has been implemented (Bationo and Buerkert, 2001; Drechsel et al., 2001; Nkonya et al., 2009; Nyssen et al., 2009; Tiffen et al., 1994). However, these programs have generally had mixed results (Longley et al., 2006; Pender et al., 2006; Place et al., 2002; Wanyama et al., 2010). It has been argued that one of the main reasons limiting replication of localized successes of SLM interventions is the socio-economic and ecological variability within African agro-ecosystems (Giller et al., 2011; Kruseman and Bade, 1998; Shepherd and Soule, 1998). Recent research has provided evidence against blanket recommendation of SLM measures within such heterogeneous regions (e.g. Ojiem, 2006; Tittonell et al., 2005). Better knowledge of farm diversity and farm efficiency is therefore essential in understanding processes driving agricultural productivity and for designing policies and programs aiming to enhance sustainable production. Moreover, because of

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the temporal dimension of land degradation (Kimetu et al., 2008), there is a need to examine how rural livelihoods change over time and how this affects farmers' interest in SLM practices.

The specific objective of this study is to analyze farm diversity and resource use efficiency of different farm types and their implications for sustainable land management strategies in the western highlands of Kenya. Specifically, we examine farm diversity and efficiency of farming systems in two sites as well as the changes in livelihood strategies between two study periods in Vihiga District. We selected the western highlands of Kenya because this area has seen one of the fastest increases in population density in SSA and land degradation and its impacts are relatively well documented (e.g. Crowley and Carter, 2000; Odendo et al., 2010; Place et al., 2006; Salasya, 2005; Shepherd and Soule, 1998; Vanlauwe et al., 2006).

The novel contributions to literature from this study include investigation of inter-temporal changes in livelihood strategies, an analysis of farm diversity, and an analysis of resource use efficiencies of different farm types. We apply the stochastic production frontier (which goes beyond the physical relationship between output and inputs) to determine whether farmers across the established farm types are allocating available resources optimally in farm production. Furthermore, we assess the implications of our detailed analysis of the heterogeneity and dynamics of farm types in Western Kenya for the promotion of SLM practices across sub-Saharan Africa. Our study thereby expands the current understanding of specific socio-economic factors that influence adoption of some of the SLM practices, which have to date been mostly analyzed at the household level (Odendo et al., 2009; Salasya, 2005).

Our findings are relevant for policies and programs aiming to promote SLM practices in the wider perspective of enhancing African rural development. SSA's population grew from about 390 million in 1980 to over 856 million people in 2010 (United Nations, 2011). Even the most conservative projections by the (United Nations, 2011), indicate that SSA's population will rise to at least 1.7 billion people, almost doubling by the year 2050. Many individual SSA countries are facing ever-increasing population growth with recent annual rates ranging between 2.4% in Mozambique and 4.4% in Zimbabwe (CIA, 2012; World Bank, 2013). Given the expected population increase in SSA in the coming decades, the population density currently encountered in Vihiga (on average 1045 people/km^2) will be representative for many other rural parts of SSA. Lessons that can be derived from experiences with promoting SLM in Vihiga (Marenya and Barrett, 2007; Odendo et al., 2009; Place et al., 2006) are therefore relevant for the design of SLM programs in many other parts of Africa.

2. Materials and methods

2.1. The study area and sampling procedure

2.1.1. Geographical location

Vihiga District covering an area of 563 km^2 is located in the highlands of Western Kenya (Fig. 1). The district lies between longitudes 34°30′ to 35°0′ East and latitudes 0°0′ to 0°5′ North. It is characterized by a gently undulating landscape sloping from West to East, with an altitude between 1300 and 2100 m above sea level. Vihiga District experiences an Equatorial climate with average rainfall ranging between 1750 and 1950 mm per year. Rainfall distribution is bimodal with a distinct long rainy season (March–June) and a short rainy season (September–November) (Government of Kenya, 2009a; Jaetzold et al., 2007). Well-drained and deep Acrisols cover 95% of the district area. The average farm size is 0.6 ha on which mixed crop and livestock farming is practiced. The district has two major agro-ecological zones: Upper Midland (UM), a high potential tea-coffee zone, and Lower Midland (LM), a maize-bean-sugar cane zone (Jaetzold et al., 2007).

2.1.2. Socio–economic characteristics

The major food crops grown include maize, beans, bananas, potatoes and sorghums. Tea, coffee and sugar cane constitute the main cash crops. Most of the cattle owned are local zebus with some improved dairy cows (Government of Kenya (2009a)). The district includes Mudete Tea Factory and has good infrastructure with tarmac and all-weather roads. Different local businesses and government agencies are located in urban centres at Mbale, Luanda, Emuhaya and Hamisi. Administratively Vihiga District has four sub-districts: Emuhaya (Emuhaya and Luanda), Hamisi (Tiriki West and East), Sabatia and Vihiga. The residents of Vihiga District are predominantly of Luhya ethnic community made up of the Tiriki found in Tiriki, the Maragoli of Sabatia and Vihiga and the Banyore residing in Emuhaya (Government of Kenya (2005)). Vihiga District is one of the most densely populated and poorest parts of Kenya. The overall population density of the district is 1045 people/km^2. Even though literacy level is over 95%, poverty incidence (*per capita* daily income of less than a dollar) is estimated at 65% of the population (KNBS, 2010).

2.1.3. Sampling design

We selected two sites—Tiriki and Emuhaya—with a slightly different farming environment for detailed household level investigation (Fig. 1). The basic unit of our sampling was the household. We adapted a working definition for a household from Ellis (1993) as a group of individuals (relatives and workers) belonging to the same rural residential place where distinct economic activities of production and consumption simultaneously occurs. Other household members also included the yet-to-detach family members working away from home but contributing to the household's assets e.g. through remittances. This is a common feature among rural households in Kenya.

For our household survey, stratified sampling was applied to demarcate areas made of groups of villages and we selected four villages from each stratum making 16 villages. In each village, we positioned a Y shaped sampling frame at a central point. We applied a random sampling technique to select five households in each direction of the Y frame, and this led to a sample of 15 households per village. Finally, we selected a total sample of 240 households but we dropped four households from the sample because they did not engage in farming activities at all during the 2009 agricultural year. At each of the sampled households, we collected detailed household and farm-level data between January and March 2010. The household head or member knowledgeable about farm and off-farm activities of the family was interviewed using a pre-tested, semi-structured questionnaire. For purposes of statistical analysis, we identified during survey the main person within the household who makes key decisions on agricultural activities as the household head interchangeably referred to as farmer.

At household level, data were collected on amounts of purchasable farm inputs, total household labor and land allocation to various enterprises. Farm outputs from the enterprises were quantified and evaluated at average selling market prices prevailing at the village level. In cases where specific prices were not reported by households that did not actually sell their produce, we imputed prices based on the averages computed from the sample at the village level. Actual prices that such households could face are likely to vary across different local markets and the timing of sale, however we assumed that any household that did not sell a specific farm output but instead consumed actually 'sold to itself' at the prevailing average local prices. Besides, we collected data on household composition, income from the farm and off-farm activities, value of farm assets and investment in crop and livestock production